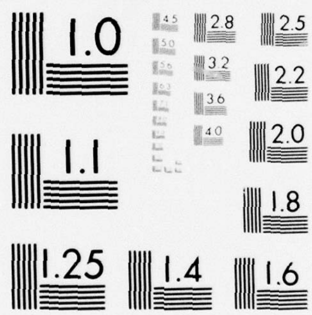

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AFCEC-TR-76-25

12
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DEVELOPMENT OF CONTOURING CAPABILITY FOR DISPLAYING RESULTS OF AIR QUALITY ASSESSMENT MODEL

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OCTOBER 1976

FINAL REPORT FOR PERIOD 1 JULY 1975 TO 1 JUNE 1976

Approved for public release; distribution unlimited

AIR FORCE CIVIL ENGINEERING CENTER
(AIR FORCE SYSTEMS COMMAND)
TYNDALL AIR FORCE BASE
FLORIDA 32401

(19) **REPORT DOCUMENTATION PAGE**

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
(18) AFCEC-TR-76-25

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER
(9)

4. TITLE (and Subtitle)
(6) DEVELOPMENT OF CONTOURING CAPABILITY FOR DISPLAYING RESULTS OF AIR QUALITY ASSESSMENT MODEL.

5. TYPE OF REPORT & PERIOD COVERED
Final rept.
1 Jul[redacted]75 — 1 Jun[redacted]76,

6. PERFORMING ORG. REPORT NUMBER
(14) CERF-EE-8

7. AUTHOR(s)
(10) Edward P. Dunphy

8. CONTRACT OR GRANT NUMBER(s)
(15) F29601-76-C-0015

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Eric H. Wang Civil Engineering Research Facility, University of New Mexico, Box 25, University Station, Albuquerque, NM 87131

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
63723F (T.D. 4.05)
(16) 2103[redacted]A23

11. CONTROLLING OFFICE NAME AND ADDRESS
Air Force Civil Engineering Center
Air Force Systems Command
Tyndall Air Force Base, FL 32401
(12) 41p.

12. REPORT DATE
(11) Oct[redacted] [redacted]76 (19) 5A

13. NUMBER OF PAGES
42

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
--

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release: distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available in DDC

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Air-Quality Modeling
Air-Quality Display
Computer Contouring
Computer Graphics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer contouring plot package has been developed to display the results of the Air Quality Assessment Model (AQAM). This program accepts input data cards or an input data tape generated on an AQAM run. Up to 20 unequal contour levels with tension parameters and dashline patterns may be specified in each contour plot. The contouring package is written for the CDC 6600 computer system.

480976

PREFACE

This report documents work performed during the period 1 July 1975 through 1 June 1976 by the University of New Mexico under contract F-29601-76-C-0015, Job Order Number 21035A23, with the Air Force Civil Engineering Center, Air Force Systems Command, Tyndall Air Force Base, Florida 32401. Capt. Dennis F. Naugle/EVA managed the program for the Center.

This report has been reviewed by the Information Officer (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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ILLUSTRATIONS

SECTION 1
INTRODUCTION

BACKGROUND

The Air Force is interested in determining the impact of airport activities on local ambient air quality. Currently, an air-quality computer model such as the Air Quality Assessment Model (AQAM) is used to evaluate the air-quality impact of airports, both in their current configurations and with proposed operational or other changes. In most air-quality models, including AQAM, a Gaussian dispersion formulation which is particularly adaptable to small distances and pollutant travel times associated with airports is used. Models based on the superimposition and addition of Gaussian plumes from point, line, or area sources have rather difficult output, which must be interpreted for assessment of environmental impact. The direct computer output of AQAM, for instance, are tables with up to 312 X- and Y-coordinates of pollution concentrations for each of five pollutants. These tables are both time consuming to read and meaningless to someone unfamiliar with air-pollution analysis. A contour-plotting routine is therefore required to graphically produce lines of equal concentrations. These contour plots can be used in conjunction with a map of an Air Force Base and vicinity for air-pollution dispersion analysis.

OBJECTIVE

To minimize the efforts of AQAM users in obtaining computer-contoured displays of AQAM predictions, the contouring package should be fully interfaced with AQAM. This could be accomplished by a contouring input tape generated during runs of AQAM. Thus, the purpose of this research effort was to develop and

implement a plot input tape mechanism to interface the AQAM short- and long-term models (refs. 1 and 2) with the contouring plot package developed at the Civil Engineering Research Facility (CERF) of the University of New Mexico and to test the contour plot package.

SCOPE

A software package was designed to accept data from cards or from a contour plot input tape generated on an AQAM run. The user should have control through an input command structure, over which data will be plotted, and the specific contour levels, their tensions and dashline patterns that would be used in each contour plot. It was decided that a driver program which would interface the user's intentions -- expressed in terms of input instructions, user data, and the contouring code -- and the system plot package was preferable to an approach in which the user would have to code a driver program for each different application and recompile the contouring program.

The data-management mechanism for AQAM calculations is developed in section 2 of this report. Since the input data matrix of predictions is typically equal to 17 by 17, it was necessary to provide linear bivariate interpolation of the original AQAM output to effectively double or triple the dimensions of the input matrix. This capability, *expansion*, is also presented. The contouring algorithm is described in section 3. Two other important code features for contour-curve fitting with splines under tension and a dashline-patterned contour-line drawing capability are also discussed. Graphic display capabilities and several examples are provided in section 4; detailed information on the required input instructions for the AQAM contour-plotting package is given in section 5; and conclusions and recommendations are contained in section 6. Examples of input instructions are also provided (appendix A) followed by examples of AQAM calculations for Scott Air Force Base (appendix B).

---

1. Wangen, L.E., and Rote, D.M., *A Generalized Air Quality Assessment Model for Air Force Operations*, AFWL-TR-74-54, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, May 1975.

2. Wangen, L.E., and Rote, D.M., *A Generalized Air Quality Assessment Model for Air Force Operations - An Operator's Guide*, AFWL-TR-74-304, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, February 1975.

SECTION 2
DATA MANAGEMENT OF AQAM PREDICTIONS

It was necessary to develop an AQAM plot restart tape format which would be well suited to the generalized model (ref. 3). AQAM-predicted concentration data fall into two categories, grid concentration data and special receptor concentration data, as shown below:

Grid Concentration Data	Special Receptor Concentration Data
P_{11} P_{12} P_{13} ...... P_{1n}	CSR_1
P_{21} P_{22} P_{23} ...... P_{2n}	CSR_2
P_{31} P_{32} P_{33} ...... P_{3n}	CSR_3
.	
.	
P_{k_1} P_{k_2} P_{k_3} ...... P_{kn}	CSR_ℓ

The mapping of grid concentration data into a list of concentrations and the concentration of special receptor data are as follows:

C_j is the concentration of pollutant for receptor grid cells j = 1, m and m = 17 x 17; CSR_i is the concentration of the i^{th} special receptor at X_i, Y_i and $\ell = 15$.

$$(C_1, C_2, C_3 \ldots\ldots C_m, CSR_1, CSR_2 \ldots CSR_\ell)$$

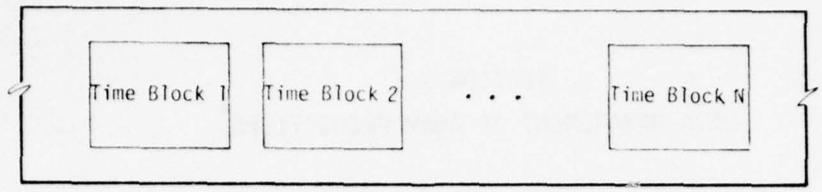
The relationship between C_j and P_{kn} (shown above) is as follows:

$$\begin{array}{ccccc} C_1 & C_2 \ldots & C_{17} & C_{18} \ldots & C_m \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ P_{11} & P_{12} \ldots & P_{1n} & P_{21} \ldots & P_{kn} \end{array}$$

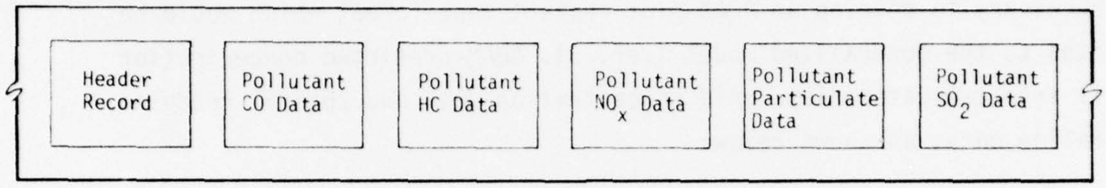
where m = 17 x 17, N = 17 by K = 17. Thus, P_{kn} is mapped into C_j where n = 1, N and k = 1, K and j = k + (n - 1)*K.

---

3. Menicucci, David F., *Air Quality Assessment Model (AQAM) Data Reduction and Operator's Guide (Draft)*, AFWL-TR-75-307, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, December 1975.



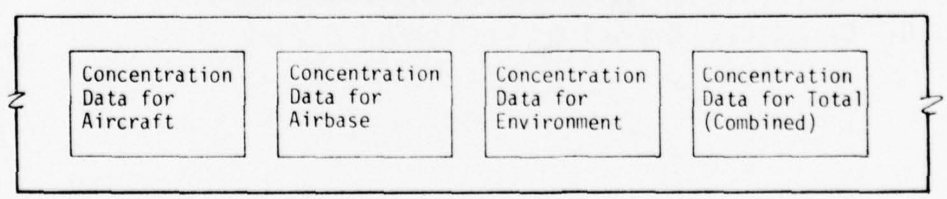
(a) Restart Tape



(b) Time Block

Parameter	Format	Variable
Time	(I10)	ICTIME
Month	(A10)	IMONTH
Weekday = 0, Weekend = 1	(I10)	IWDOE
Title	(A10)	ITITLE(8)
Number of Pollutants	(I10)	NPOL
Pollutants	(A10)	IPOLL(5)
X- and Y-Coordinates of Lower Left Corner of Receptor Grid	(F10.3)	XYCRG(2)
Number of Rows	(I10)	NROW
Number of Columns	(I10)	NCOL
X- and Y-Grid Spacing	(F10.3)	XYSP
Number of Special Receptors	(I10)	NSRP
X- and Y-Coordinates of Special Receptor	(F10.3)	XYSPE(30)
Meteorological Data		
Stability Category	(I10)	ISC
Wind Speed (m/sec)	(F10.3)	WS
Wind Direction (deg)	(F10.3)	WD
Temperature (°F)	(F10.3)	TEMP
Mixing Depth (m)	(F10.3)	DMID

(c) Header Record



(d) Pollutant Data Block

Figure 1. Structure of AQAM Contouring Input Tape

The contouring input tape contains several time blocks as shown in figure 1a. Each time block contains a header record and a pollutant data block for each of five pollutant types as illustrated in figure 1b. The format of the header record is shown in figure 1c. Each pollutant data block contains concentration data for the four source classifications: aircraft, airbase, environment, and total (fig. 1d).

The AQAM receptor grid represents a sampling domain in two dimensions, in which model calculations are made. The lower left-hand corner of the grid, the number of rows and columns, and the spacing between mesh points are chosen by the user. The typical AQAM grid size is 17 by 17, but rectangular grids can be used as long as the total receptors are less than 312. The smoothness of the contours is dependent both on the tension of the contour and the rank of dimension of the AQAM receptor grid. The expansion capability allows the user to double or triple the dimension of the original receptor grid through a simple linear bivariate interpolation algorithm. It is generally felt that the interpolated matrix contains no more real information than did the original matrix. AQAM predictions at special receptor locations within the receptor grid are likely to show much higher concentrations than predictions at mesh points because of their proximity to sources when taking into account meteorological conditions. The expansion capability is beneficial when one must use a receptor grid that is small (less than 12 by 12) or when there are spikes in the grid predictions.

SECTION 3
CONTOURING ALGORITHM

The development of the AQAM contouring program involved the establishment of a data-preparation mechanism and computer software, modification and implementation of existing software packages, and concatenation of all software with system plot packages. A literature search was performed but very little useful information on computer contouring was found. The contouring programs available from computer software companies were either too expensive, too complicated in general, produced contour plots of insufficient quality and accuracy, or required too much effort in terms of input on the part of the applications programmers.

CONREC CONTOURING CODE

Communications with Mr. Tom Wright of the National Center for Atmospheric Research (NCAR) indicated that a contouring code named CONREC, in use at NCAR, might be adapted for use in conjunction with AQAM. CONREC, authored by Mr. Tom Wright, is a Fortran callable subroutine for two-dimensional contour plotting (ref. 4). CONREC accepts a two-dimensional array of input data to be contoured. For each contour level the algorithm searches along the perimeters of the input matrix, interrogating successive mesh points. In the event the mesh point to the left is less than or equal to the contour value which is also greater than the mesh point to the right, the algorithm finds the starting position for a given contour level. A subprogram is called to trace the contour from this starting position by linearly interpolating the neighboring mesh points. The inequality between left and right mesh points and bookkeeping in the subprogram which traces the contour line guarantee that no contour will be drawn twice. The internal rows of mesh points of the input array are similarly searched for starting positions, and each contour is traced in turn from its starting position. This procedure is repeated for each contour level. The contour lines which are to be labeled are drawn first.

---

4. Wright, T.J., *Utility Plotting Programs at NCAR*, Atmospheric Technology, National Center for Atmospheric Research, September 1973.

In the smoothing version of this algorithm, the linearly interpolated points for each contour line are smoothed by splines under tension (ref. 5). The smoothed contour lines are then labeled by a software dashline subroutine.

The operating system and the Fortran compiler at NCAR, however, are not standard CDC software. Computer codes at NCAR are not compatible with the standard CDC 6600 compilers like those at AFWL. More specifically, nonstandard input, output, and shifting operations are handled differently by the Fortran compilers at these installations. It was therefore necessary to modify the NCAR routines which had NCAR system dependencies and add codes appropriate to the standard CDC Fortran FTN 4.2 compiler. Linking the contouring code to the AFWL system plot package was accomplished with a set of stop-gap routines.

CONREC was also modified to allow for greater user control, and hence flexibility, in the type of contours generated. Data structures which allow the user to specify unequal contour levels, a tension parameter used in smoothing, and the dashline pattern for each contour line were implemented.

Smooth contours which do not overlap must be obtained by both adjusting the tension parameter and by increasing the resolution of the input array. A subroutine which increases the input mesh data from N by K to 2N - 1 by 2K - 1 was programmed by averaging neighboring points for bivariate linear interpolation. Other resolution-increasing techniques such as bicubic spline interpolation tend to produce oscillatory interpolation for typical AQAM concentration data because of the rapidly changing derivatives in the concentration surface and therefore were not considered.

SPLINES UNDER TENSION

Two important requirements for contour maps are that contour lines not intersect and each contour line be smooth. A number of curve-fitting techniques which allow for curve smoothing have been developed, but when they are applied

---

5. Cline, A.K., "Scalar-and-Planar-Valued Curve Fitting Using Splines Under Tension", *Comm ACM*, Vol. 17, No.4, April 1974, pp. 218-223.

to contour plotting, smooth contour lines which overlap or intersect result. A.K. Cline (ref. 5) using splines under tension has developed techniques for planar curve fitting. Both opened (nonperiodic) and closed (periodic) curves are considered. The important characteristic of splines under tension, as opposed to other curve-smoothing and interpolation techniques, is that with sufficient tension a curve can be drawn as close as desired to polygonal lines drawn through the knots and still be smooth. A unique feature of the AQAM contour-plotting program is the capability of specifying the tension parameter for fitting smooth contour lines for a particular contour level. This is important in contouring air-pollution concentrations. Typically, there are large spikes in the concentration surface. When contours are drawn at levels which are changing rapidly--corresponding to large partial derivatives in the concentration surface--the resolution of the data for that contour is typically very low. This means that the contour curve is based on only a few knots. An increase in resolution may provide more knots on which to base the contour. To circumvent the need for unreasonably high resolution data, splines under tension can be used effectively to insure that contours which are based on a small number of knots do not intersect. In terms of AQAM contouring applications, the implication is that low tension can be specified for low contour levels and greater tension can be specified for higher contour levels where there is a possibility that the low resolution of the data together with insufficient tension will produce an intersection of contour lines. The dimensionless tension parameter ranges from 1 to 30. Figure 2 illustrates the effect of tensions 1 to 9 on curves drawn through four knots.

DASHLINE PATTERNS

Some choices of contour levels inevitably produce small contours without labels which indicate the height of the contour. These may be level curves near the top of a spike or local maxima. Dashline patterns can be used effectively when this situation occurs; i.e., the pattern of the line identifies the level even though it has no label. Thus, the user by specifying a dashline pattern for each contour level can enhance the clarity of the contour plot. These patterns and their numbers are given in figure 3.

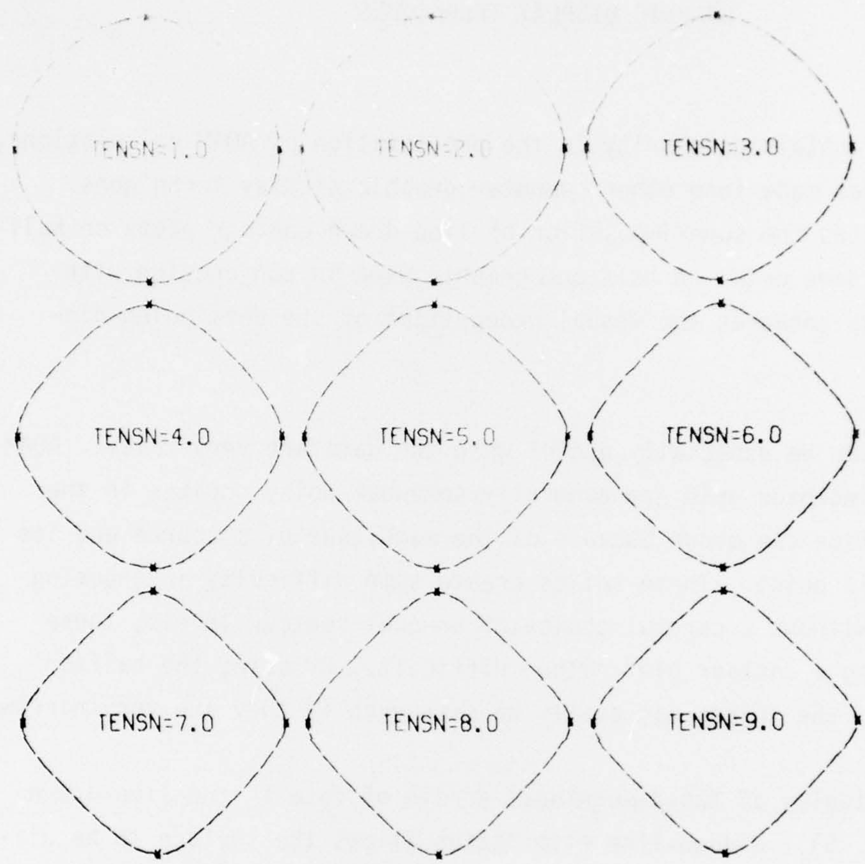


Figure 2. Effect of Tension Parameter

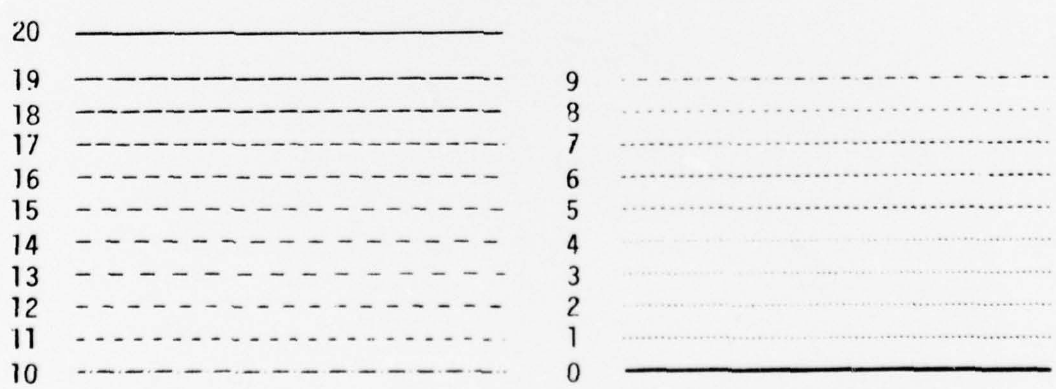


Figure 3. Dashline Patterns

SECTION 4
GRAPHIC DISPLAY TECHNIQUES

In the interest of obtaining clarity in the presentation of AQAM calculations, an investigation was made into other computer graphic display techniques. Figure 4 illustrates the superimposition of line-drawn contour plots on halftone plots of the same data. A halftone graphic used in conjunction with line-drawn contours enhances the visual recognition of the data being displayed.

Halftone shading can be especially useful when the data are very noisy. AQAM predictions on a receptor grid are generally somewhat noisy; spikes in the concentration surface can occur because of the magnitude of a source and its proximity to a grid point. These spikes create some difficulty in choosing contour levels. Without a careful choice of unequal contour levels, these spikes make reading a contour plot rather difficult. By using the halftone shading technique, the spikes can easily be seen even if they are very narrow.

Another graphic display of two-dimensional arrays of data is the line-drawn surface plot (fig. 5). Hidden-line elimination allows the surface to be displayed as though it were opaque or solid. Figure 5 also demonstrates the effect of increasing the resolution (from 17 x 17 to 33 x 33) by the linear, resolution-increasing, expansion technique.

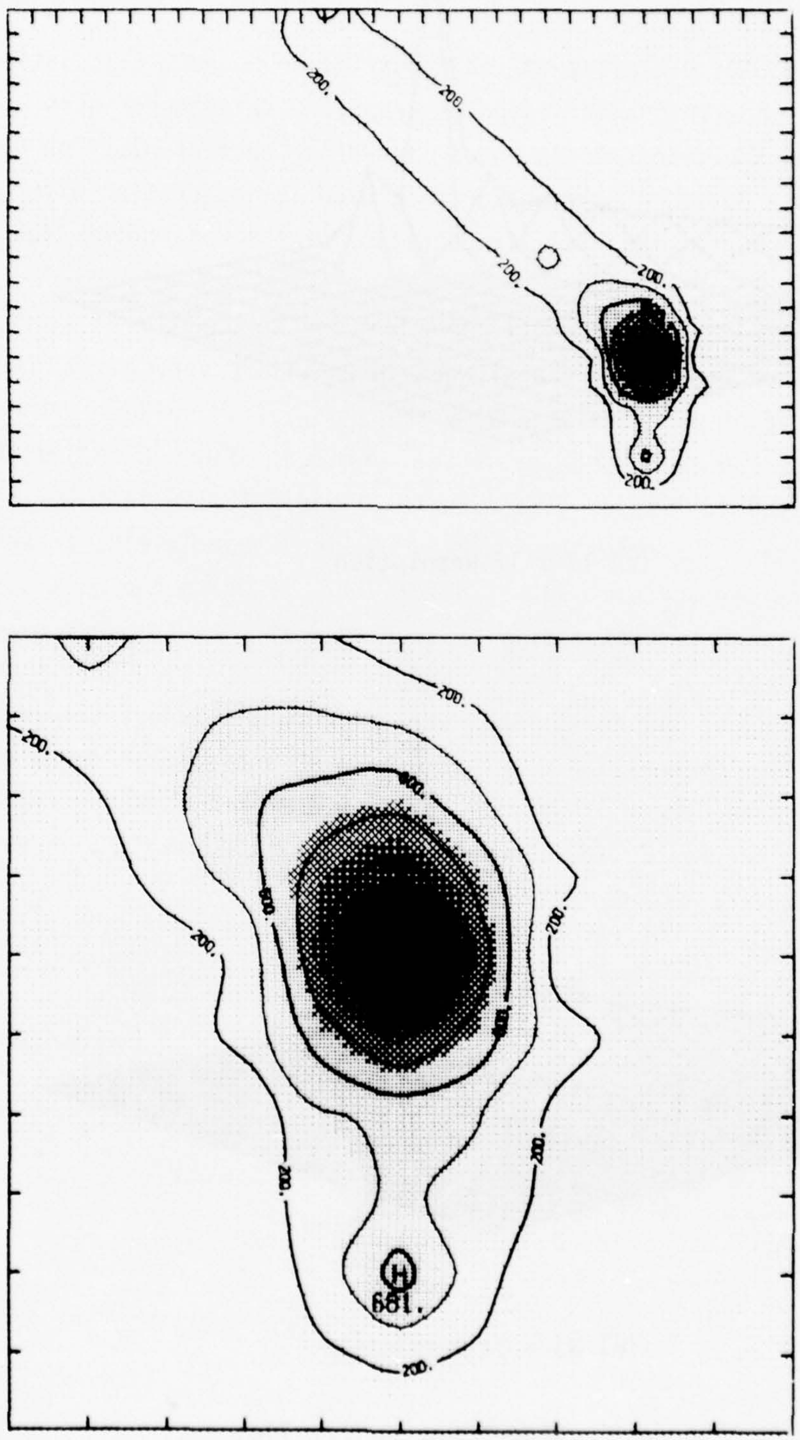
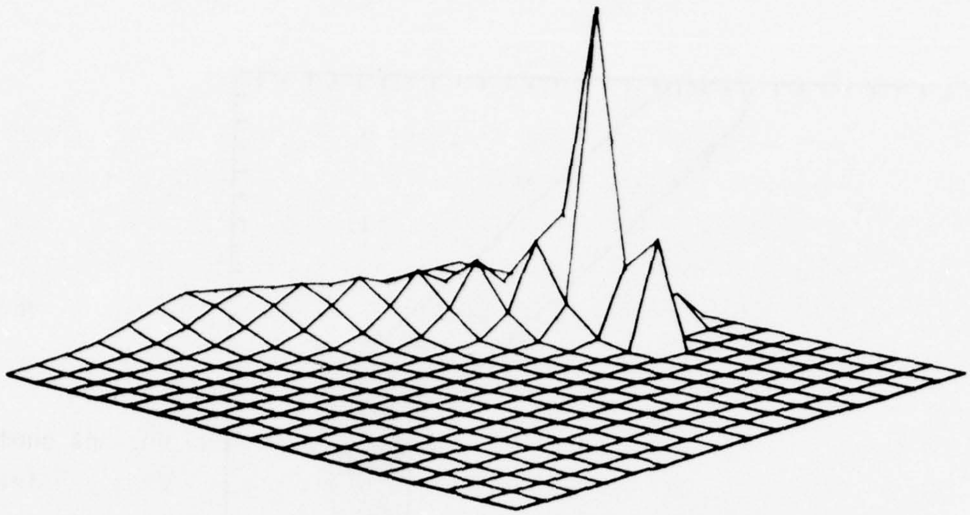
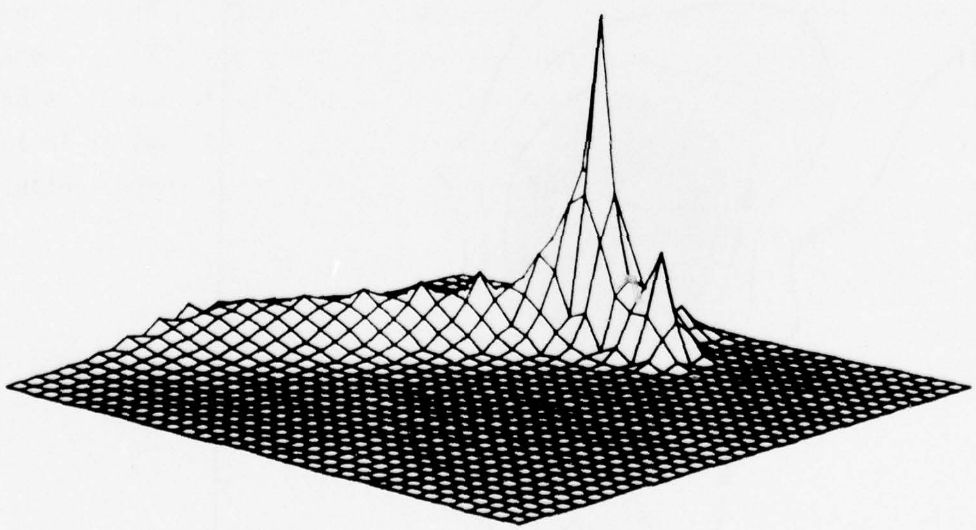


Figure 4. Halftone and Contour Lines



(a) 17 x 17 Resolution



(b) 33 x 33 Resolution

Figure 5. Line-Drawn Surface Plot

SECTION 5
INPUT INSTRUCTIONS

The input cards are used as follows: to retrieve a specified time block from the restart data tape; to select options such as various sources, pollutants, and special receptors; to perform special operations such as different contour levels and tensions; and to alter the content of the title as given on the input tape. Command cards are utilized to allow as much flexibility as possible. They are described below:

GETTIME DEFAULT	- search for a specified time block and process with default options.
GETTIME CARD	- read data on punched cards immediately following the command card. This is used when the restart data tape is not available.
TITLE	- read text on the next punched card to override the title given by the restart tape.
OPTION	- read the following punched cards which contain the data on contour levels, tensions, and dashline patterns. This option is effective only during the current GETTIME.
END OF OPTION	- end of contour option data.
END OF JOB	- end job.
NO LEGEND	- eliminate the legend from the plot.

The minimum input data cards for a successful run are any number of GETTIME cards and an END OF JOB card. Between 10 and 30 contour levels are generated, and the number of levels is dependent upon the input data.

GETTIME DEFAULT Card (one card required)

Columns	Variable	Format	Description
1-7	GETTIME	(A10)	Input Command
11-17	DEFAULT	(A10)	Input Command
21-22	LS	(A2)	ST = Short-Term Model LT = Long-Term Model
23-26	ICTME	(A4)	Time Block Descriptor

Columns	Variable	Format	Description
31-34	ISO	(4I1)	Source Column / Source ISO(1) 31 Aircraft ISO(2) 32 Airport ISO(3) 33 Environment ISO(4) 34 Total If ISO(n)=1, the n^{th} sources will be plotted and all others will be ignored. Default: all sources will be plotted.
41-45	IPO	(5I1)	Pollutant Column / Source IPO(1) 41 CO IPO(2) 42 HC IPO(3) 43 NO_x IPO(4) 44 Particulate IPO(5) 45 SO_2 If IPO(n)=1, the n^{th} pollutants will be plotted and all others will be ignored. Default: all pollutants will be plotted.
51-55	IEXP	(5I1)	Expansion of Matrix Column / Source IEXP(1) 51 CO IEXP(2) 52 HC IEXP(3) 53 NO_x IEXP(4) 54 Particulate IEXP(5) 55 SO_2 If IEXP(n)=0, the original matrix with rank NCOL, NROW will be contoured. If IEXP(n)=1, the matrix will be expanded to (2 x NCOL)-1, (2 x NROW)-1. If IEXP(n)=2, the matrix from the first expansion will be expanded again. i.e., NCOL=10 NROW=12 IEXP(n)=0 gives 10 x 12 IEXP(n)=1 gives 19 x 23 IEXP(n)=2 gives 37 x 45 No default values.

Columns	Variable	Format	Description
61-65	ISPEC	(5I1)	Special Receptor

	Column	Pollutant
ISPEC(1)	61	CO
ISPEC(2)	62	HC
ISPEC(3)	63	NO_x
ISPEC(4)	64	Particulate
ISPEC(5)	65	SO_2

If ISPEC(n)=1, special receptors of the n^{th} pollutants will be plotted.
Default: Special receptors will be ignored.

GETTIME CARD Card (minimum of three cards required)

Card 1

Columns	Variable	Format	Description
1-7	GETTIME		Command
11-14	CARD		Command

Card 2 and successive cards necessary for this group of data are to be read in as namelist group. This means that keywords are required to be punched for corresponding values. See reference manual (ref. 6). The following keywords are used in this group and are explained in the restart tape format:

ICTIME - not necessary
IMONTH - octal
IWDOE - integer
ITITLE(8) - octal
IPOLL(5) - octal
XYCRG(2) - real
NROW - integer
NCOL - integer
XYSP - real
NSRP - integer
ISC - integer
WS - real
WD - real
TEMP - real
DMID - real
ISORCS(4) - octal
NPOL - integer

6. *Fortran Extended Version 4 Reference Manual*, Control Data Corporation, Cyber 70 Computer Systems Models 72, 73, 74, 76, 7600 Computer System and 6000 Computer System, 1974.

ISO	-	integer
IPOL	-	integer
IEXP	-	integer
ISPEC	-	integer

Cards numbered from n + 1 on are the concentration data.

TITLE Card (two cards required)

Columns	Variable	Format	Description
1-5	TITLE		Command
1-80	INTIT	(8A10)	Command

CONTOUR OPTION Card

Card 1

Columns	Variable	Format	Description
1-6	OPTION		Command

Card 2

Columns	Variable	Format	Description
11-20	CONL	(F10.3)	Contour Level
21-31	TENS	(F10.3)	Tensions
31-41	LNP	(I10)	Dashline Pattern

Card 3 is the same as CONTOUR OPTION Card 2 for next contour level.

.

.

.

Card n-1 (Note: Contour levels must be read in ascending order. A maximum of 20 may be inputted.)

Card n

Columns	Variable	Format	Description
1-10	END OF OPT		Command

NO LEGEND Card (one card optional)

Columns	Variable	Format	Description
1-9	NO LEGEND		Command

END OF JOB Card (one card required)

Columns	Variable	Format	Description
1-10	END OF JOB		Command

As described under GETTIME CARD, some of the variables being read in as a namelist group must be converted from characters to display code as follows:

A	01	P	16	4	31
B	02	Q	17	5	32
C	03	R	18	6	33
D	04	S	19	7	34
E	05	T	20	8	35
F	06	U	21	9	36
G	07	V	22	+	37
H	08	W	23	-	38
I	09	X	24	*	39
J	10	Y	25	/	40
K	11	Z	26	(	41
L	12	0	27	)	42
M	13	1	28	Blank	45
N	14	2	29	Comma	46
O	15	3	30	Period	47

Consider as an example that one wishes to have the month on the plot read SEPT for September. The namelist input will then read:

IMONTH=19051620454545454545B.

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

(1) The software package is extremely fast; it requires only about 3 sec of execution time per contour plot for a 17 x 17 matrix.

(2) The input command structure requires a minimum amount of input information but allows the user to directly control the display of AQAM calculations.

(3) The contouring package is fully interfaced with the AQAM via the contouring input tape generated during AQAM runs.

(4) Plots produced by the contouring package can be automatically labeled, if desired, with appropriate information.

(5) The package has been implemented on the CDC 6600 Computer System at Eglin Air Force Base and is connected via intercom to a DATA 100 system at Tyndall Air Force Base. Plotting will be done on a Calcomp 936 plotter at the Air Force Civil Engineering Center, Tyndall Air Force Base.

(6) The AQAM contouring package represents the state-of-the-art in computer graphic display of two-dimensional contours.

(7) The user can easily control the content of the graphic output.

Recommendations for future research and development which are beyond the scope of this technical effort are as follows:

(1) The halftone technique described in this report should be implemented.

(2) An effort should be made to develop methods for analysis of graphic display of concentration data. An example of this type of analysis is the computation of areas enclosed by contours for each contour level. Another might be the computation and display of the rate of change of the concentrations over the grid.

(3) Techniques for the overlay of digital cartography of an airbase map and vicinity on contour plots should be explored.

(4) Techniques for producing camera-ready, report-quality graphics at minimum expense should be developed.

(5) The contouring code should be adjusted so that very small contours are not plotted.

REFERENCES

1. Wangen, L.E., and Rote, D.M., *A Generalized Air Quality Assessment Model for Air Force Operations*, AFWL-TR-74-54, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, May 1975.

2. Wangen, L.E., and Rote, D.M., *A Generalized Air Quality Assessment Model For Air Force Operations - An Operator's Guide*, AFWL-TR-74-304, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, February 1975.

3. Menicucci, David F., *Air Quality Assessment Model (AQAM) Data Reduction and Operator's Guide (Draft)*, AFWL-TR-75-307, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, December 1975.

4. Wright, T.J., *Utility Plotting Programs at NCAR*, Atmospheric Technology, National Center for Atmospheric Research, September 1973.

5. Cline, A.K., "Scalar-and-Planar-Valued Curve Fitting Using Splines Under Tension", *Comm ACM*, Vol. 17, No. 4, April 1974, pp. 218-223.

6. *Fortran Extended Version 4 Reference Manual*, Control Data Corporation, Cyber 70 Computer Systems Models 72, 73, 74, 76, 7600 Computer System and 6000 Computer System, 1974.

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APPENDIX A

EXAMPLES OF INPUT INSTRUCTIONS FOR CONTOURING TAPE AND CARD INPUT

CONTOURING WITH TAPE OR DISK FILE INPUT

The sample contour plots were generated from predictions made by AQAM for Scott Air Force Base, Illinois. Figure A1 demonstrates the result of GETTIME DEFAULT with automatic contouring; figure A2 demonstrates the use of GETTIME DEFAULT with contour OPTIONS for the same data. The Scott graphics in appendix B illustrate the technique for the overlay of a line-drawn contour plot on a halftone graphic of an airbase map. The input instructions for contouring with tape input (figs. A1 and A2) are as follows:

```
1      7/8/9
2      G         0        ST0600        1      1
3      TITLE
4      SCOTT AFB AND AFCS AND C130  (BASE AND VICINITY)   GRID SPACING .6 KM
5      G         0        ST0600        1      1
6      TITLE
7      SCOTT AFB AND AFCS AND C130  (BASE AND VICINITY)   GRID SPACING .6 KM
8      OPTION
9                100.     2.5                  0
10               250.     2.5                  4
11               500.     5.5                  4
12               900.     5.5                  4
13     END OF OPT
14     END OF JOB
15     6/7/8/9
```

The first GETTIME DEFAULT results in automatic contour level selection by the program. Contour options for the same data are specified in the second GETTIME DEFAULT.

Dashline patterns can be used to readily identify contour levels of special interest. In the examples, the higher contour levels are drawn with solid lines. The relationship of the airbase map and vicinity to the contour plot is determined by the initial choice of the location of the AQAM (X,Y) grid. Photoreproduction techniques ensure an accurate overlay. The airbase map is photoreduced and screened before being overlaid with the contour plot.

CONTOURING WITH CARD INPUT

The following example illustrates the full input instruction set for card input. The contour plot produced by these input instructions would be the same as that shown in figure A2.

```
7/8/9
G            0
 $INCAR
  ICTIME=27,33,27,27,38,27,34,27,27,45,
  IMONTH=10,05,16,20,05,13,02,05,18,45,
  IWDOE=0,
  XYCRG=244.240,4266.800,
  NROW=17,
  NCOL=17,
  XYSP=.50,
  NSRP=9,
  ISC=6,
  WS=1.00,
  WD=130.00,
  TEMP=62.0,
  DMID=100.0,
  IEXP(1)=0,
  ISPEC(0)=0,
  ISO(4)=1,
  IPO(1)=1,
  NPOLL=5$

1.431E-06
1.527E-04
5.260E-03
3.570E-02
7.342E-01
3.732E+00
1.276E+01
3.217E+01
6.399E+01
1.054E+02
1.495E+02
1.883E+02
2.156E+02
2.291E+02
2.294E+02
2.193E+02

1.503E-06
2.146E-04
8.467E-03
1.300E-01
1.321E+00
5.578E+00
2.147E+01
5.100E+01
9.497E+01
1.461E+02
1.936E+02
2.283E+02
2.458E+02
2.467E+02
2.345E+02
2.137E+02

1.517E-06
3.218E-04
1.452E-02
2.782E-01
2.497E+00
1.198E+01
3.667E+01
8.085E+01
1.390E+02
1.974E+02
2.420E+02
2.651E+02
2.668E+02
2.519E+02
2.267E+02
1.963E+02

1.437E-06
5.234E-04
2.693E-02
5.528E-01
4.981E+00
2.250E+01
6.317E+01
1.269E+02
1.984E+02
2.564E+02
2.876E+02
2.905E+02
2.720E+02
2.409E+02
2.045E+02
1.680E+02
```

90		135	2.386E+02	180	1.039E+03
91	1.223E-06	136	2.224E+02	181	6.167E+02
92	3.418E-04	137	1.650E+02	182	4.926E+02
93	5.507E-02	138	1.134E+02	183	3.112E+02
94	1.192E+00	139	8.509E+01	184	1.925E+02
95	1.054E+01	140	5.021E+01	185	1.237E+02
96	4.326E+01	141		186	7.945E+01
97	1.086E+02	142	1.318E-07	187	5.054E+01
98	1.944E+02	143	1.432E-02	188	3.173E+01
99	2.710E+02	144	1.598E+00	189	1.985E+01
100	3.142E+02	145	2.815E+01	190	1.241E+01
101	3.190E+02	146	1.343E+02	191	7.798E+00
102	2.953E+02	147	2.926E+02	192	
103	2.562E+02	148	4.266E+02	193	
104	2.121E+02	149	4.515E+02	194	2.370E-04
105	1.695E+02	150	3.913E+02	195	6.711E+01
106	1.320E+02	151	3.031E+02	196	1.058E+03
107		152	2.216E+02	197	8.971E+02
108	8.618E-07	153	1.567E+02	198	5.613E+02
109	1.924E-03	154	1.084E+02	199	2.768E+02
110	1.272E-01	155	7.416E+01	200	1.533E+02
111	2.943E+00	156	5.053E+01	201	1.041E+02
112	2.368E+01	157	3.443E+01	202	6.778E+01
113	8.410E+01	158		203	4.146E+01
114	1.829E+02	159	1.502E-05	204	2.444E+01
115	2.943E+02	160	1.168E-01	205	1.419E+01
116	3.458E+02	161	5.449E+00	206	8.228E+00
117	3.538E+02	162	1.573E+02	207	4.827E+00
118	3.225E+02	163	3.040E+02	208	2.879E+00
119	2.724E+02	164	4.755E+02	209	
120	2.185E+02	165	5.195E+02	210	1.750E-10
121	1.689E+02	166	4.348E+02	211	6.801E-04
122	1.271E+02	167	3.127E+02	212	1.167E+00
123	9.410E+01	168	2.132E+02	213	1.232E+03
124		169	1.429E+02	214	2.332E+03
125	4.186E-07	170	9.450E+01	215	1.830E+02
126	4.667E-03	171	6.207E+01	216	1.121E+02
127	3.409E-01	172	4.069E+01	217	1.066E+02
128	7.812E+00	173	2.667E+01	218	6.487E+01
129	5.586E+01	174	1.752E+01	219	3.535E+01
130	1.612E+02	175		220	1.813E+01
131	2.932E+02	176	6.918E-11	221	9.227E+00
132	3.832E+02	177	4.792E+00	222	4.777E+00
133	3.970E+02	178	1.710E+02	223	2.542E+00
134	3.542E+02	179	4.521E+02	224	1.401E+00

225	7.938E-01
226	
227	5.116E-09
228	2.947E-03
229	1.784E+02
230	1.682E+02
231	1.018E+02
232	1.514E+02
233	1.593E+02
234	6.608E+01
235	2.732E+01
236	1.081E+01
237	4.478E+00
238	1.981E+00
239	9.391E-01
240	4.740E-01
241	2.535E-01
242	1.423E-01
243	
244	
245	3.562E-03
246	6.383E-01
247	7.893E+01
248	2.100E+02
249	5.783E+02
250	1.212E+02
251	1.501E+01
252	3.067E+00
253	9.787E-01
254	3.721E-01
255	1.621E-01
256	7.844E-02
257	4.128E-02
258	2.325E-02
259	1.383E-02
260	
261	
262	6.334E-02
263	3.012E+00
264	1.413E+02
265	5.092E+01
266	7.510E-01
267	4.726E+01
268	7.888E-01
269	2.583E-02
270	1.003E-02
271	5.341E-03
272	3.099E-03
273	1.321E-03
274	1.251 -03
275	8.454 -04
276	5.896 -04
277	
278	
279	3.058 -01
280	1.245 -01
281	4.248 -02
282	2.023 -02
283	1.141 -03
284	4.088 -04
285	2.068 -02
286	1.128 -04
287	4.624 -05
288	2.885 -05
289	8.459 -06
290	8.067 -06
291	8.281 -06
292	8.122 -06
293	7.873 -06
294	
295	
296	1.697 -07
297	
298	
299	1.433 -04
300	6.788 -07
301	6.868 -09
302	6.020 -09
303	6.163 -09
304	5.784 -09
305	5.185 -09
306	4.534 -09
307	3.912 -09
308	1.732 -08
309	2.434 -08
310	3.350 -08
311	3.077 +02
312	5.718 +02
313	1.621 +02
314	3.191 +02

```
4.095 +02
2.025 +02
3.058 +02
2.176 +02
1.812 +02
TITLE
SCOTT AFCS AND C130 (BASE AND VICINITY)  GIRD SPACING .6 KM
OPTION
             100.       3.5                 0
             250.       5.5                 4
             500.       5.5                 4
             900.       5.5                 4
END OF OPT
END OF JOB
6/7/8/9
```

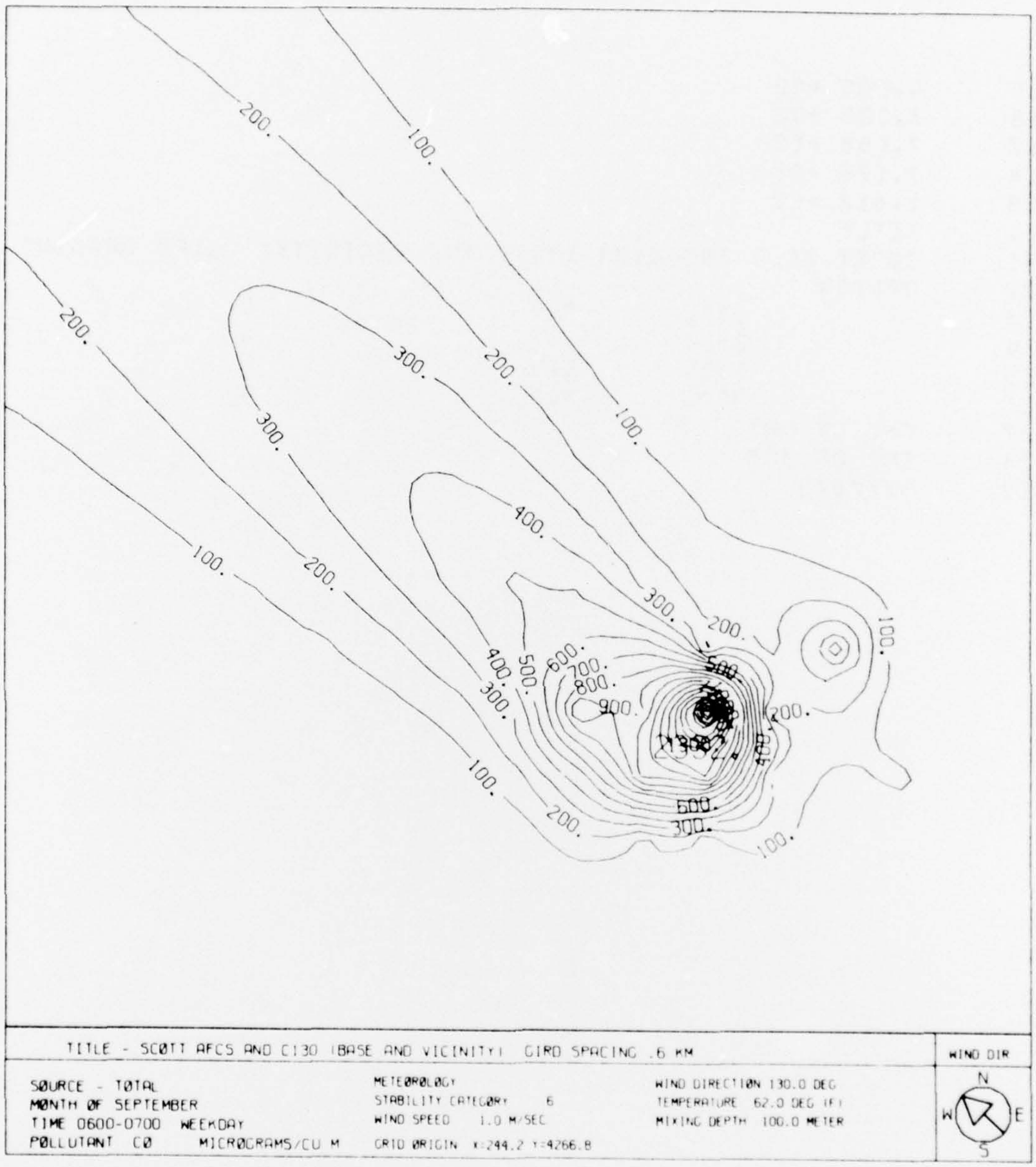


Figure A1. Automatic Contour

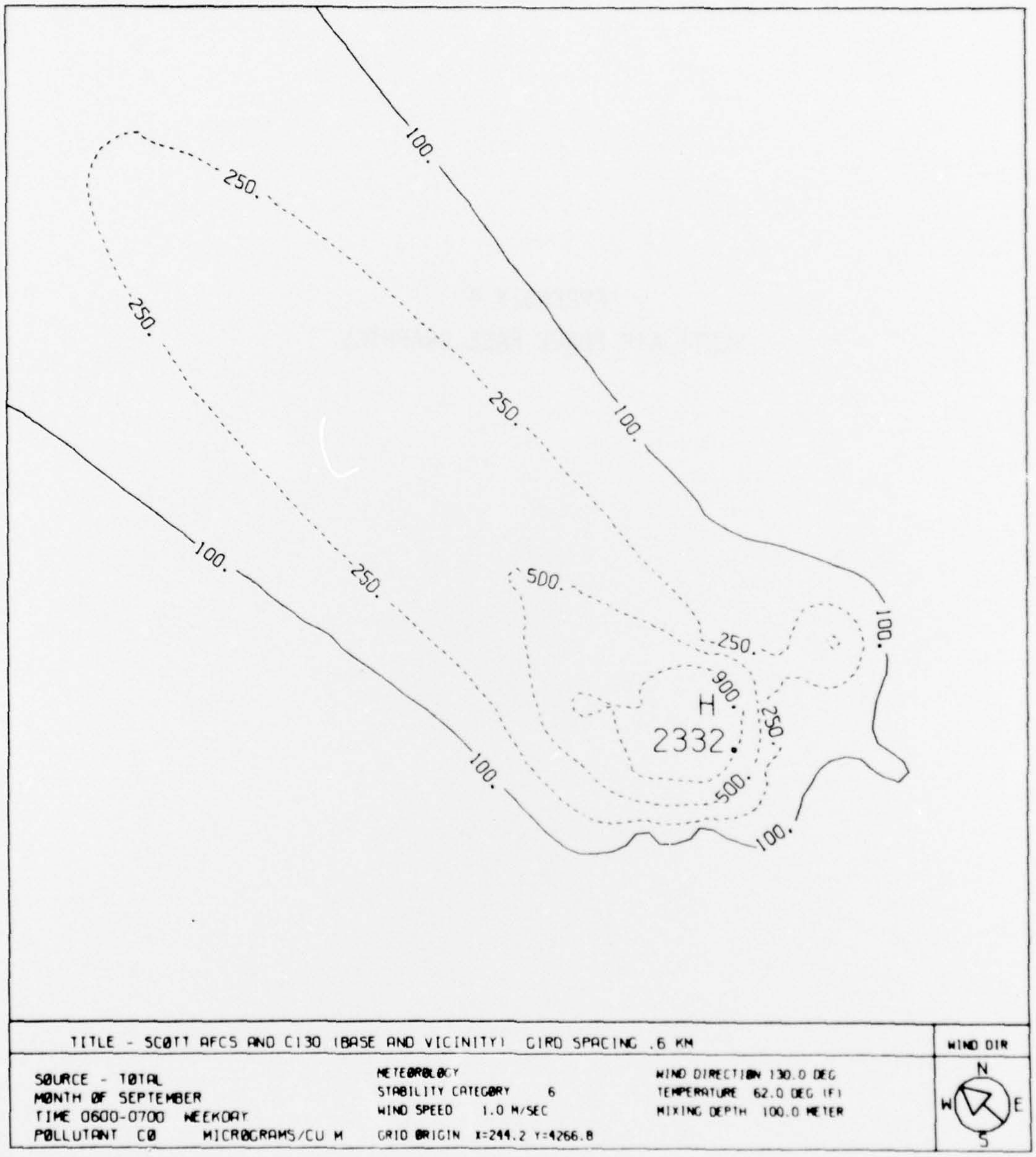
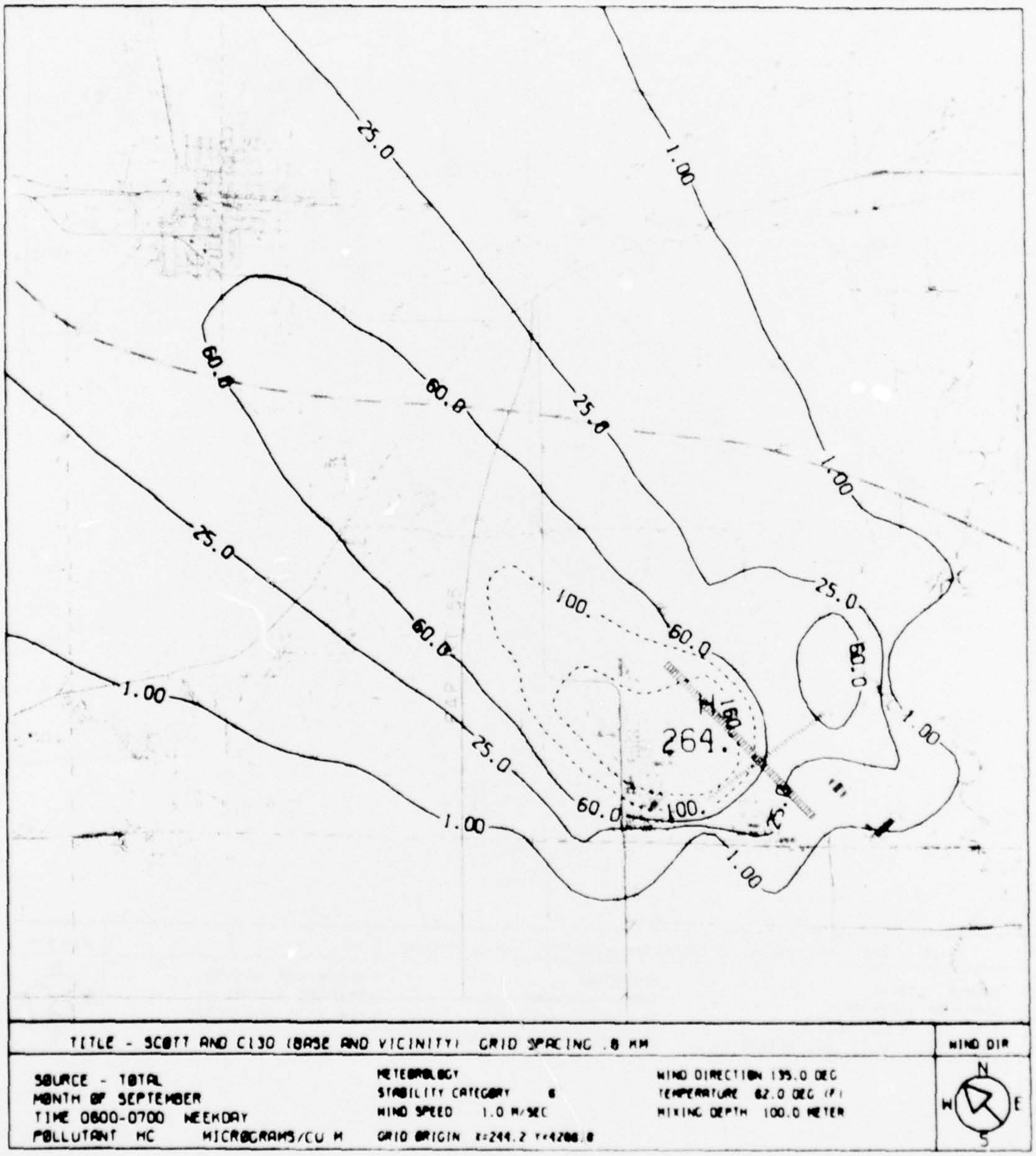


Figure A2. Contour with Options

APPENDIX B

SCOTT AIR FORCE BASE GRAPHICS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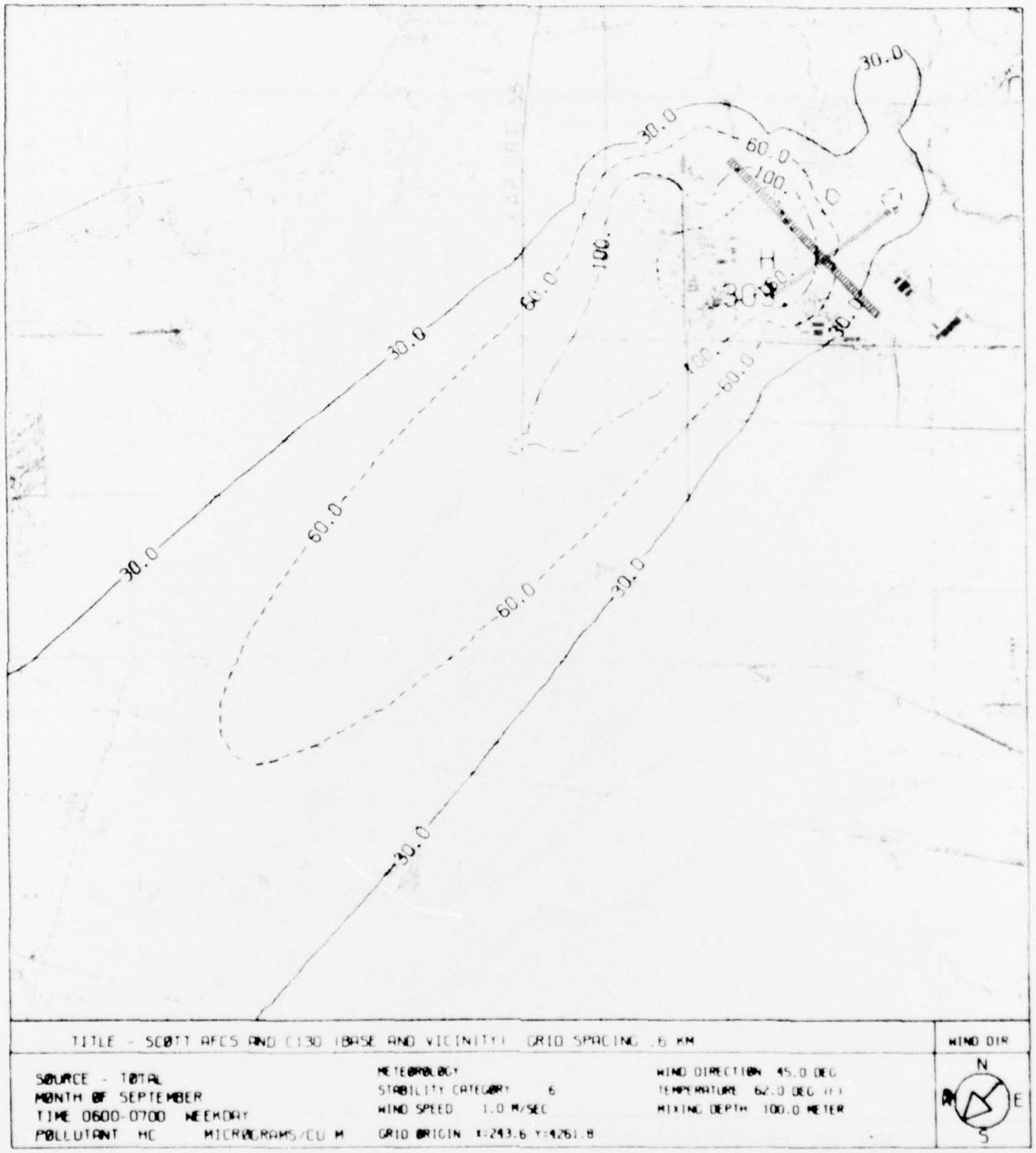
1.00
60.0
25.0
1.00
25.0
60.0
100.
60.0
60.0
264.
25.0
1.00
60.0
100.
1.00
1.00
TITLE - SCOTT AND C130 (BASE AND VICINITY) GRID SPACING .8 KM
WIND DIR
SOURCE - TOTAL
MONTH OF SEPTEMBER
TIME 0600-0700 WEEKDAY
POLLUTANT HC MICROGRAMS/CU M
METEOROLOGY
STABILITY CATEGORY 6
WIND SPEED 1.0 M/SEC
GRID ORIGIN X=244.2 Y=4208.0
WIND DIRECTION 135.0 DEG
TEMPERATURE 82.0 DEG (F)
MIXING DEPTH 100.0 METER
N
W
E
S


30.0
60.0
100.
309.
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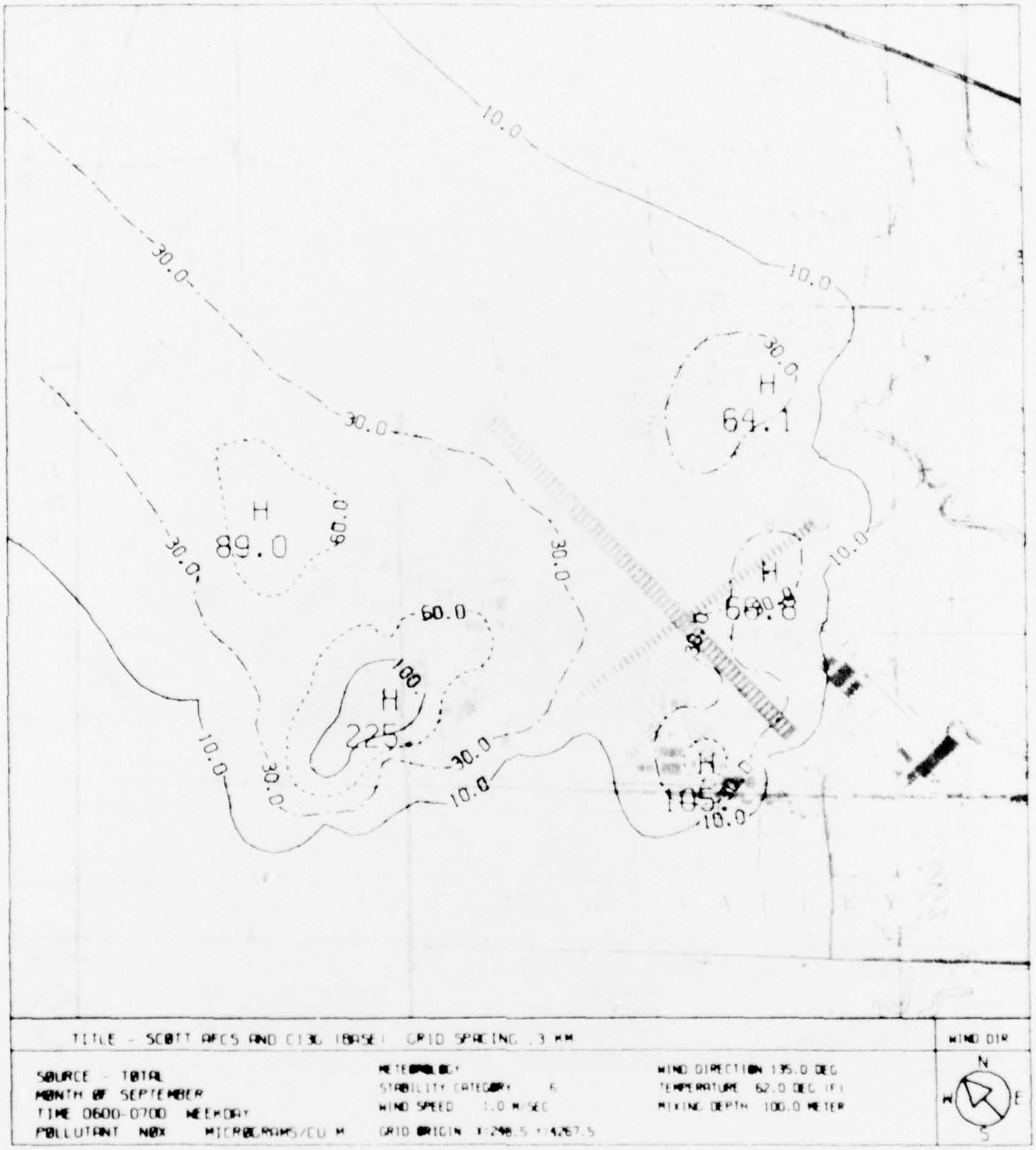
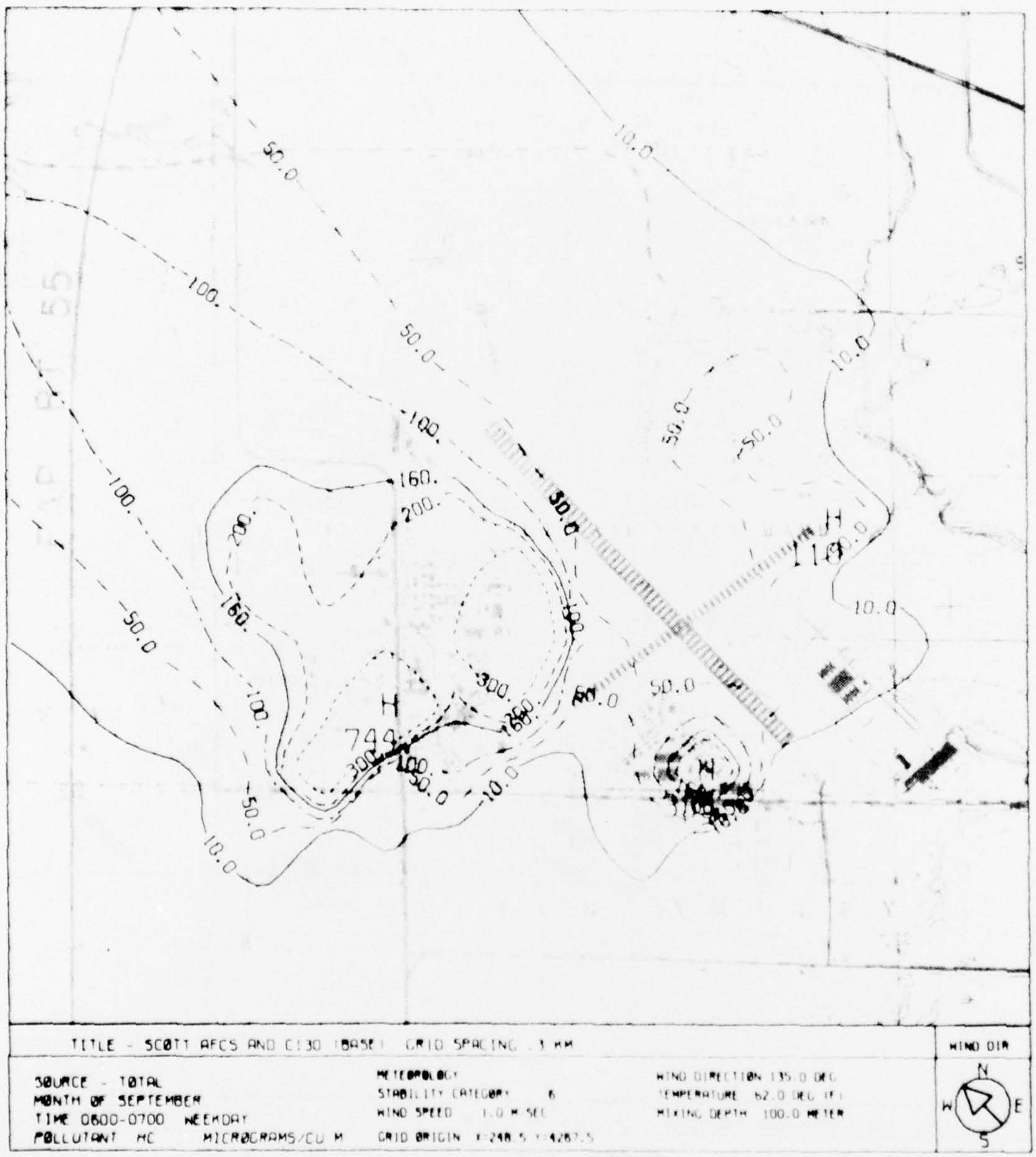
SØURCE - TØTAL
MØNTH ØF SEPTEMBER
TIME 0600-0700 WEEKDAY
PØLLUTANT HC MICRØGRAMS/CU M
METEØRØLOGY
STABILITY CATEGØRY 6
WIND SPEED 1.0 M/SEC
GRID ØRIGIN X=243.6 Y=4261.8
WIND DIRECTIØN 45.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER
N
E
S


10.0
30.0
H
64.1
H
89.0
60.0
H
225.
100
H
105.
TITLE - SCØTT AFCS AND C13G (BASE) GRID SPACING .3 KM
WIND DIR
SØURCE - TØTAL
MØNTH ØF SEPTEMBER
TIME 0600-0700 WEEKDAY
PØLLUTANT NØX MICRØGRAMS/CU M
METEØRØLØGY
STABILITY CATEGØRY 6
WIND SPEED 1.0 M/SEC
GRID ØRIGIN X:248.5 Y:4267.5
WIND DIRECTIØN 135.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER
N
W
E
S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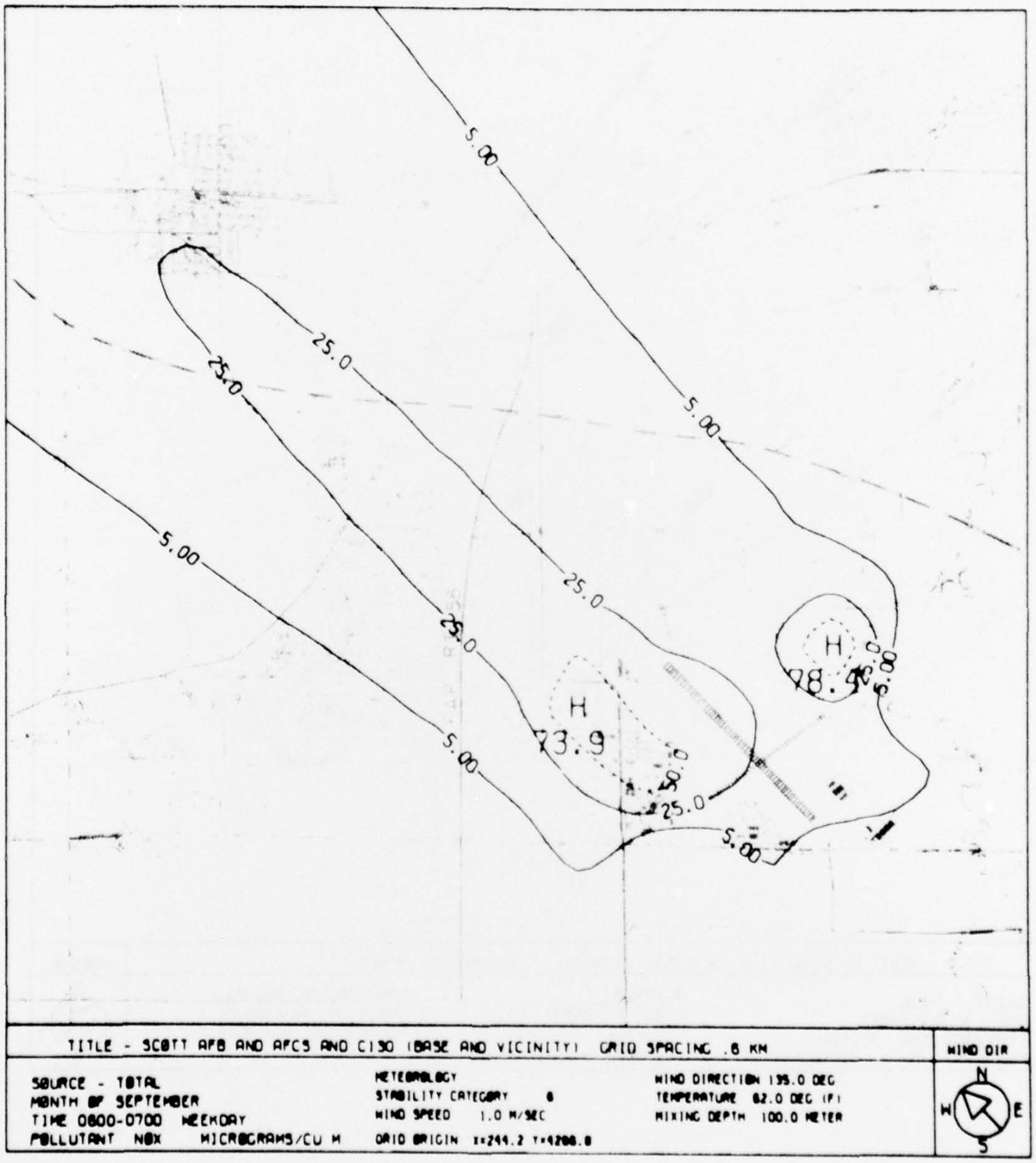
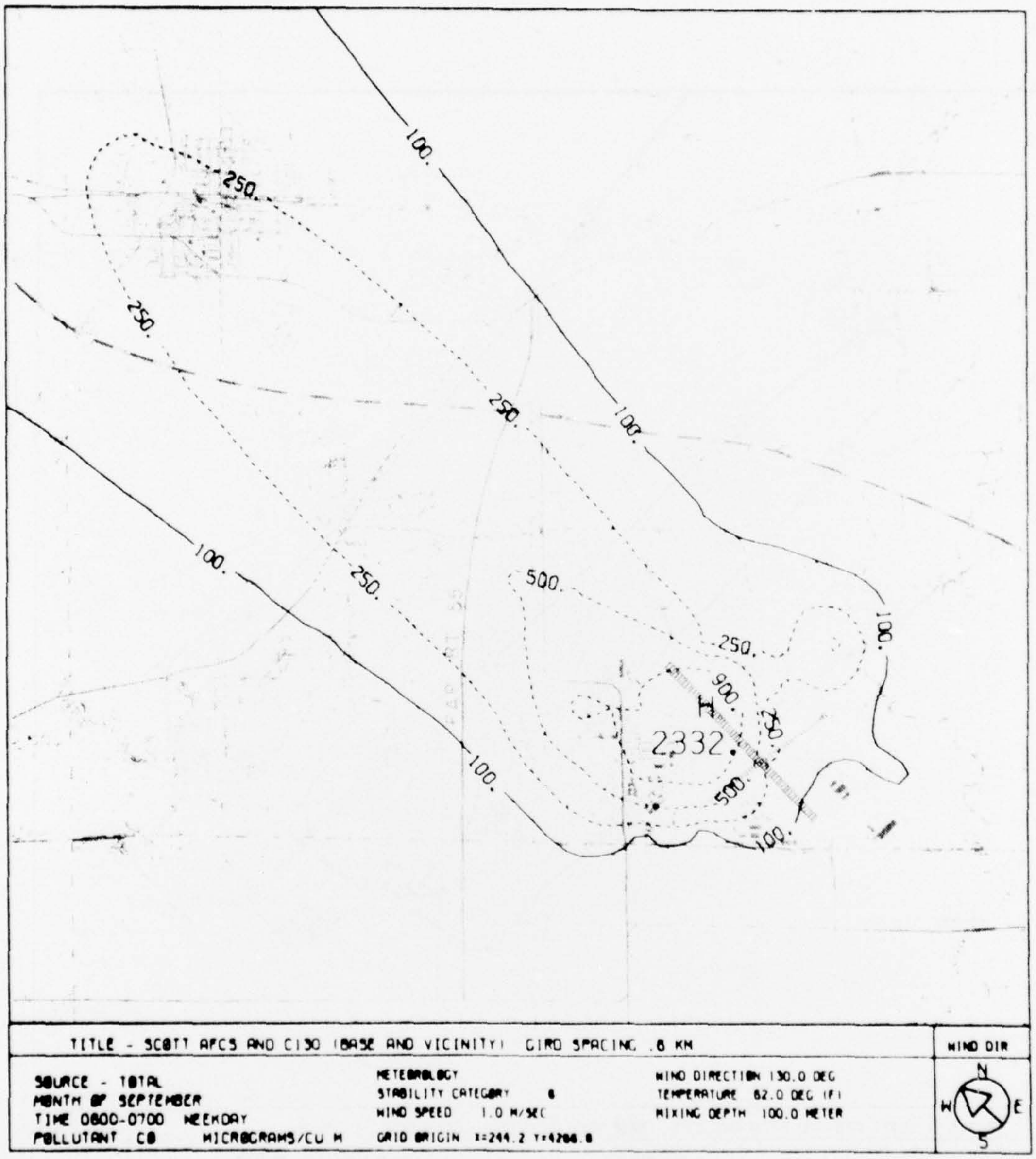
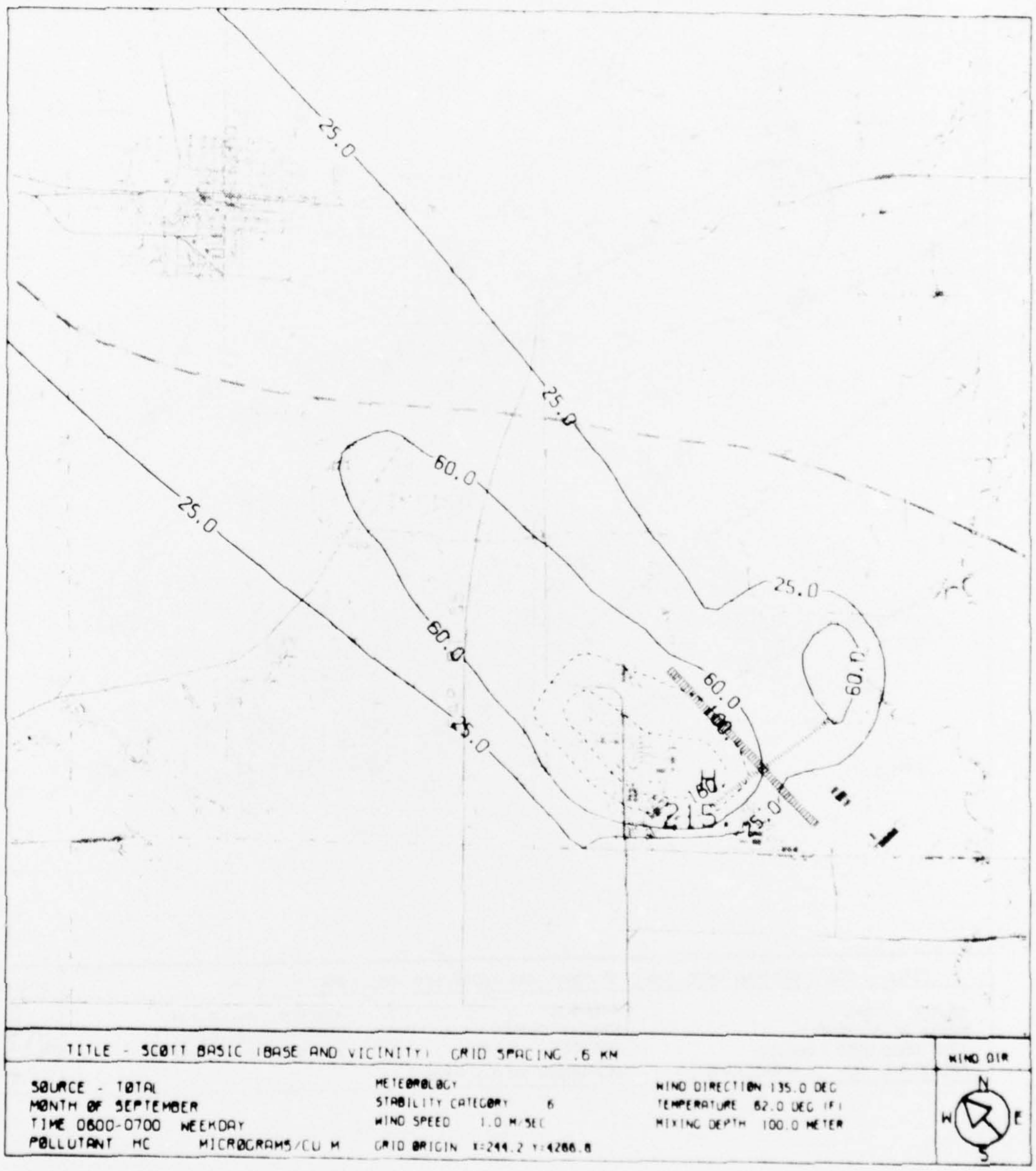
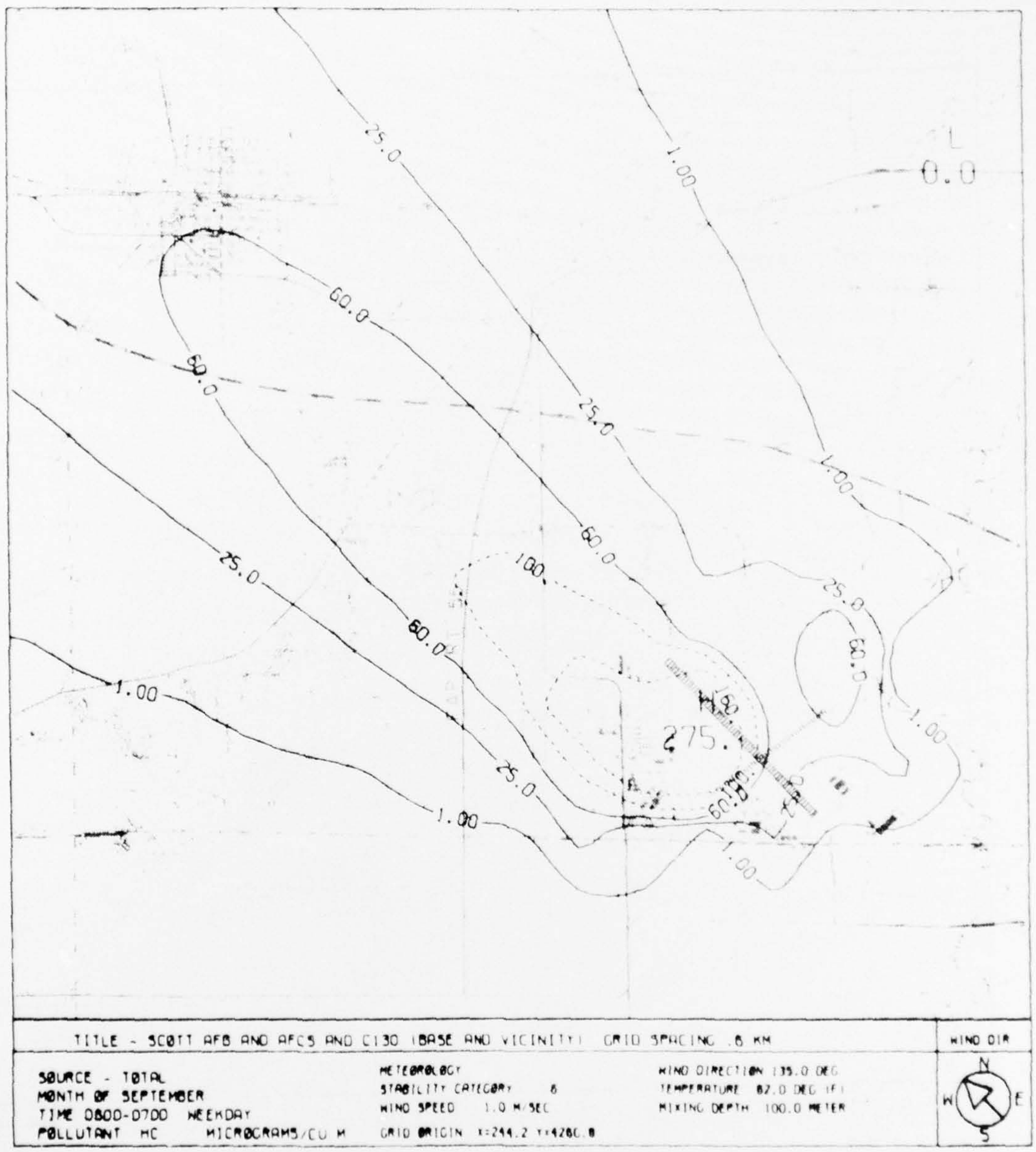
WIND DIR
SØURCE - TØTAL
MØNTH ØF SEPTEMBER
TIME 0600-0700 WEEKDAY
PØLLUTANT HC MICRØGRAMS/CU M
METEØRØLØGY
STABILITY CATEGØRY 6
WIND SPEED 1.0 M SEC
GRID ØRIGIN X=248.5 Y=4287.5
WIND DIRECTIØN 135.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER
N
W
E
S


5.00
25.0
H
73.9
98.4
TITLE - SCOTT AFB AND AFCS AND C130 (BASE AND VICINITY) GRID SPACING .8 KM
WIND DIR
SOURCE - TOTAL
MONTH OF SEPTEMBER
TIME 0600-0700 WEEKDAY
POLLUTANT NOX MICROGRAMS/CU M
METEOROLOGY
STABILITY CATEGORY 6
WIND SPEED 1.0 M/SEC
GRID ORIGIN X=244.2 Y=4200.0
WIND DIRECTION 135.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER
N
W
E
S


100.
250.
250.
250.
100.
100.
250.
500.
100.
250.
900.
250.
H
2332.
100.
500.
100.
TITLE - SCOTT AFCS AND C130 (BASE AND VICINITY) GIRD SPACING .8 KM
WIND DIR
N
W
E
S
SOURCE - TOTAL
MONTH OF SEPTEMBER
TIME 0600-0700 WEEKDAY
POLLUTANT CO MICROGRAMS/CU M
METEOROLOGY
STABILITY CATEGORY 6
WIND SPEED 1.0 M/SEC
GRID ORIGIN X=244.2 Y=4266.8
WIND DIRECTION 130.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER


25.0
25.0
60.0
25.0
25.0
60.0
60.0
60.0
25.0
215.
TITLE - SCØTT BASIC (BASE AND VICINITY) GRID SPACING .6 KM
WIND DIR
N
W
E
S
SØURCE - TØTAL
MØNTH ØF SEPTEMBER
TIME 0600-0700 WEEKDAY
PØLLUTANT HC MICRØGRAMS/CU M
METEØRØLØGY
STABILITY CATEGØRY 6
WIND SPEED 1.0 M/SEC
GRID ØRIGIN X=244.2 Y=4286.8
WIND DIRECTIØN 135.0 DEG
TEMPERATURE 62.0 DEG (F)
MIXING DEPTH 100.0 METER


25.0
1.00
0.0
60.0
100
275.
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WIND DIR
N
W
E
S
SØURCE - TØTAL
MØNTH ØF SEPTEMBER
TIME 0800-0700 WEEKDAY
PØLLUTANT HC MICRØGRAMS/CU M
METEØRØLØGY
STABILITY CATEGØRY 6
WIND SPEED 1.0 M/SEC
GRID ØRIGIN X=244.2 Y=4280.8
WIND DIRECTIØN 135.0 DEG
TEMPERATURE 82.0 DEG (F)
MIXING DEPTH 100.0 METER

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TAC/SGPB	1
OEHL/CC	1
OEHL/OL-AA	1
OEHL/OL-AB	1
DDC/TCA	12
NARF, Code 64270	2
Naval Postgraduate School	2
Naval Air Propulsion Test Ctr	1
AFCEC/XR(Tech Library)	1
AFCEC/EV	1
AFCEC/EVA	5
AFCEC/DEE	2
AFCEC/WE	2
AUL (AUL-LSE-70-239)	1
AFATL/DLOSL	2

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